

Mr. W. H. Power's Report to the Local Government Board on Diphtheria at the Hospital for Sick Children, Great Ormond Street.

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THIS inquiry, ordered by the Board at the instance of the Medical Committee of the Hospital for Sick Children, has sought a cause for diphtheria occurring in that institution during March of this year.

The outbreak in question is without parallel in the history of the hospital. In-patients have heretofore rarely been attacked by diphtheria; and when this has happened it has been under circumstances consistent with extension of the disease from antecedent cases under treatment in particular wards. On the present occasion, in-patients of four out of the five general wards of the hospital were almost simultaneously attacked by diphtheria or scarlatina, and this under circumstances that seemed to exclude, at least in the majority of cases, antecedent human infection. Preliminary inquiry by a sub-committee of the medical staff of the hospital, led, in view of the above and of other evidence, to suspicion that the outbreak had been related to dust which had permeated the hospital during demolition of buildings in its neighbourhood. In the end it will be seen that much doubt attached to this view, although the suspicion could not wholly be set aside.

The inquiry that I have made has not succeeded in demonstrating a cause of the diphtheria. Its failure in that sense has been chiefly due to the complexity of the conditions inquired about. Invasion of the hospital by diphtheria could not, of course, be considered apart from a nearly simultaneous invasion of certain of the wards by scarlatina; nor could the fact be overlooked that among the after occurrences of illness, there were—besides diphtheria, scarlatina, and sore throats of an anomalous sort—cases also of whooping cough and measles apparently originating in the hospital.

The mere enumeration of these circumstances will indicate something of the difficulties which the inquiry had to encounter. The facts, as they soon presented themselves for examination, are summed up in the following tables:—

TABLE I. (a.)

Disease contracted in the Hospital.	Date of Invasion.	Patient in Hospital before Attack.	Ward occupied by Patient before Attack.	Name and Age of Patient.	Malady for which Patient was admitted.	Result of inter-current illness.
Scarlatina -	5th March	45 days	Louise	Ewens, 3	Abdominal abscess	Recovered.
Diphtheria -	8th "	26 "	Alexandra	Thurston, 9 $\frac{3}{12}$	Chorea -	Died, 14th March.
Nasal diphtheria -	9th "	19 "	Alice	Ashford, 1 $\frac{3}{12}$	Phthisis -	Died, 11th April.
Diphtheria -	9th "	27 "	Do.	Simpson, 4 $\frac{3}{12}$	Meningitis -	Died, 16th March.
Diphtheria -	10th "	6 "	Do.	Kirby, 5 $\frac{2}{12}$	Rheumatism -	Recovered.
Diphtheria -	10th "	13 "	Victoria	Warner, 2 $\frac{5}{12}$	Pneumonia -	Died, 13th March.
Scarlatina -	10th "	Months	Alexandra	A nurse, adult	-	Recovered.
Tonsillitis -	10th "	29 days	Alice	Rossiter, 5 $\frac{1}{12}$	Cerebral tumour -	Do.
Acute albuminuria -	11th "	44 "	Alexandra	Martin, 5 $\frac{1}{12}$	Phthisis -	Do.
Whooping cough -	11th "	23 "	Alice	Jordan, 2 $\frac{3}{12}$	Empyema -	Do.
Swollen tonsils -	10th-14th "	37 "	Do.	Moule, 3 $\frac{1}{12}$	Brain case -	Do.
Swollen tonsils -	10th-14th "	55 "	Do.	Blacknell, 3 $\frac{1}{12}$	Brain case -	Do.

TABLE 1. (a).—continued.

Disease contracted in the Hospital.	Date of Invasion.	Patient in Hospital before Attack.	Ward occupied by Patient before Attack.	Name and Age of Patient.	Malady for which Patient was admitted.	Result of inter-current illness.
Follicular tonsillitis	12th March	22 days	Helena	Back, 4 $\frac{3}{4}$	Curvature of spine	Recovered.
Sore throat -	13th „	13 „	Alice	Thorne, 11 $\frac{1}{2}$	Psoriasis -	Do.
Scarlatina -	17th „	200 „	Louise	Stratton, 7 $\frac{2}{3}$	Nævoid tumour -	Do.
Measles -	19th „	39 „	Do.	Hodges, 7 $\frac{1}{2}$	Diseased knee -	Do.
Diphtheria -	23rd „	18 „	Do.	Cavannah, 3 $\frac{1}{2}$	Wryneck -	Died.
Diphtheria -	24th „	43 „	Victoria	Burgess, 8 $\frac{5}{8}$	Lardaceous disease	Recovered.
Diphtheria -	24th „	14 „	Do.	Wilson, 4 $\frac{5}{8}$	Typhoid fever -	Do.
Sore mouth -	24th „	48 „	Do.	Andrews, 3 $\frac{4}{8}$	Ulceration of bowels	Do.
Diphtheria -	End of „	13 „	Alice	Robson, 3 $\frac{3}{8}$	Rickets -	Died.

TABLE I. (b.)

Disease for which admitted to Hospital.	Date of Attack.	Date of Admission.	Ward occupied by Patient.	Name and Age.	Result of Illness.
Diphtheria -	1st week of April	9th April	Alice	Page, 4 $\frac{1}{2}$ -	Recovered.
Diphtheria -	2nd week of April	13th April	Do.	Cann, 2 $\frac{1}{8}$ -	Do.
Diphtheria -	19th April -	21st April	Do.	Resident House Physician.	Do.

The inquiry was directed to search for conditions coincident with the distribution of the diphtheria; and though, in the result, no coincidences were found of a nature to demonstrate the cause of the disease, some facts were learnt that deserve record here. They need to be prefaced by a few words concerning the hospital arrangements.

The main hospital is a three-story building, with a central administrative portion, and with north and south wings containing the “general” wards, each of some 20 beds. Other wards, provided for isolation of cases of infectious sickness, are contained in a building termed the “North Block,” which is separate and distinct from the main hospital. The medical wards of the hospital proper are, the “Victoria” on the ground floor, and the “Alice” on the first floor of the north wing, and the “Alexandra” on the ground floor of the south wing. The surgical wards are the “Helena” on the first floor and the “Louise” on the second floor of the south wing. The second floor of the north wing principally gives accommodation to the nursing staff, but a small diphtheria ward and a “quarantine” ward are also placed here. Each general ward has its own closets and bath-room placed in projections of the building on either side of the end of the wing.

The wards in the north wing are drained and ventilated apart from the wards of the south wing, and apart also from those of the “North” or isolation “Block.” Wards of the north wing drain into an old parish sewer that crosses the hospital grounds in its course from Queen’s Square to Lamb’s Conduit Street. Those of the south wing drain to the main sewer in Great Ormond Street. Fresh air to the wards, closets, and bath-rooms is introduced by open windows and air-valves in the outer walls; while special gratings in the middle of the ceilings are provided for the exit of air. The gratings in the ward ceilings communicate with a vertical shaft in the middle of the wing; those in the bath-room and closet ceilings pass to ventilating turrets, two at the end of each wing. In the several turrets are “exhaust chambers” heated by hot-water coils, into which air is drawn, not only from closets and bath-rooms,* but also from the drains of the hospital. Into the exhaust

* It is doubtful whether air is drawn directly from the wards into these exhaust chambers, or indirectly only by way of closets and bath-rooms. In each exhaust chamber there enters a shaft labelled “from angle of ward;” but it is affirmed that the shafts so labelled are all of them super-numerary and unused shafts with “blind” lower ends. This may be true of three shafts thus labelled which enter three out of the four turret chambers, for no air current could be detected in them. But in the fourth “angle of ward” shaft (that entering the north-eastern turret chamber) a free upward current of air was noticeable.

chambers provided in each turret at the end of the wing, ventilators from soil pipes, slop sink-pipes, and bath waste-pipes open by free ends; while into the eastern turret chamber of each wing there enters also a ventilating pipe from the trap of the main drain of the wing. These arrangements were noted as likely to be of importance if passage of air from one ward to another or of drain air into the wards should come in question. It needs to be added that beyond the various openings into exhaust chambers no other ventilating openings are provided to the hospital drains; the various closet and discharge pipes are carefully trapped, and no inlets for fresh air are provided.

Incidentally the above details show that as regards drainage and ventilation, which are possible agencies for the propagation of infection, the two wings of the hospital had little or nothing in common; in both respects they were distinct and separate one from the other. It has now to be noted that in certain other respects the two wings, with their contained wards, had much in common; and this in the direction of conditions that might possibly have had concern with the outbreak. *Water supply.*—The water supply of the hospital is from the mains of the New River Company. For drinking purposes water is stored in two cisterns (one for each wing) situated in the roof of the administrative block. Though separated by a considerable interval, these cisterns are connected together by piping, and must therefore be regarded as constituting a single supply. Drinking water for use in the wards is obtained in each instance from a tap in the “kitchen” of the ward. The supply of water (cold) to baths, closets, and housemaids’ sinks is separate for each wing, and is obtained from cisterns situate in each of the four turrets already referred to. The source of supply of heated water is common to both wings. *Food.*—All food for use in the hospital is received in the central administrative block, and is thence distributed to the wards. Hence the wards must be regarded as obtaining food from a common source. Cooking operations are performed in the main kitchen of the hospital in the basement of the central block. Beyond warming of milk, beef tea, and the like, no cooking is conducted in the ward kitchens. *In the Laundry arrangements* there is community of circumstance for the several general wards. *Administrative intercommunication* between the wings occurs by means of the resident medical staff, and of the three “Sisters,” each of whom has charge (on the same floor) of a ward in each wing. The Lady Superintendent and the Registrar of the hospital have naturally habitual access to both wings and all wards. The nurses are, while on duty, separate for each ward.

At the date of the outbreak, the North (isolation) Block and the diphtheria ward had been for several weeks void of cases, while the five general wards of the hospital were practically full, and contained 102 patients. This number was within a few days of the outbreak reduced to 40; by discharge of such patients as could be sent to their homes and by removal of convalescents to Highgate. Admission of fresh cases to hospital at the same time ceased. On 14th March the Alice Ward was adopted for the treatment of diphtheria cases, which up to this time had been dealt with in the diphtheria ward; scarlet fever was, as usual, treated in isolation in the North Block, and all other medical cases that had to be retained were collected in Victoria Ward. The retained surgical cases (which were more numerous than the medical ones) continued to occupy their own wards, Helena and Louise.

For the purpose of this inquiry the facts of the outbreak have been grouped and regrouped in various ways with a hope of obtaining indications as to the cause of the diphtheria. For the purpose of recording some of the main features of the evidence got together, it will be enough, in supplement to the table already given, to formulate these facts as follows:—

TABLE II.

Particulars of Ward.	Infectious Diseases occurring among Patients.					Remarks respecting the Cases.
	Name and Age.	Stay in Hospital before Attack.	Date of Attack.	Illness.	Where fell ill.	
Louise. (Surgical.) South Wing.	Ewens, 3	Days. 45	5th Mar.	Scarlatina	Louise	Transferred to North Block 5th March.
	Stratton, 7 $\frac{3}{12}$	200	17th Mar.	Scarlatina	At home	Discharged, 16th March. Members of family subsequently attacked.
	Hodges, 7 $\frac{1}{2}$	39	19th Mar.	Measles	Do.	Discharged 16th March.
	Cavannah, 3 $\frac{1}{12}$	18	23rd Mar.	Diphtheria	Do.	Discharged 14th March. Died after re-admission to hospital.
Alexandra. (Medical.) South Wing.	Thurstan, 9 $\frac{6}{12}$	26	8th Mar.	Diphtheria	Alexandra	Transferred to Diphtheria Ward 10th March. Died 14th March.
	Nurse Warner, adult.	—	10th Mar.	Scarlatina	Alexandra	Removed at once to North Block. Had measles 26th March.
Alice. (Medical.) North Wing.	Martin, 5 $\frac{1}{2}$	44	11th Mar.	Acute albuminuria.	Do.	Removed 13th March to Victoria. Had sore mouth there 24th March.
	Ashford, 1 $\frac{3}{12}$	19	9th Mar.	Nasal diphtheria.	Alice	Transferred to Victoria 14th March. Laryngitis 9th April. Died 11th April.
	Simpson, 4 $\frac{3}{12}$	27	9th Mar.	Diphtheria	Do.	To Diphtheria Ward 10th March. To Alice 14th March. Died.
	Kirby, 5 $\frac{2}{12}$	6	10th Mar.	Diphtheria	Do.	To Diphtheria Ward 10th March. To Alice 14th March. Recovered.
	Rossiter, 5 $\frac{1}{12}$	29	10th Mar.	Tonsillitis	Do.	Retained in Alice until discharge in April.
	Jordan, 2 $\frac{3}{12}$	23	11th Mar.	Whooping cough.	Do.	Removed to St. Bartholomew's 12th March.
	Thorne, 11 $\frac{1}{12}$	13	13th Mar.	Sore throat	Do.	Discharged 13th March.
	Moule, 3 $\frac{1}{12}$	37	10th-14th Mar.	Swollen tonsils	Do.	To Victoria 13th March, and there treated. Was under belladonna.
	Blacknell, 3 $\frac{1}{12}$	55	10th-14th Mar.	Swollen tonsils	Do.	To Victoria 13th March, and there treated. Had whooping cough in April.
	Robson, 3 $\frac{3}{12}$	13	End of Mar.	Diphtheria	At home	Discharged 13th March. Died at home.
Victoria. (Medical.) North Wing.	Warner, 2 $\frac{5}{12}$	13	10th Mar.	Diphtheria	Victoria	Transferred to Diphtheria Ward 10th March. Died 13th March.
	Burgess, 8 $\frac{5}{12}$	43	24th Mar.	Diphtheria	Do.	Retained in Victoria. Died of meningitis.
	Wilson, 4 $\frac{5}{12}$	14	24th Mar.	Diphtheria	Do.	Retained in Victoria.
	Andrews, 3 $\frac{4}{12}$	48	24th Mar.	Sore mouth	Do.	Retained in Victoria. Died of bowel mischief.
Helena. (Surgical.) South Wing.	Back, 4 $\frac{4}{12}$	22	12th Mar.	Follicular Tonsillitis.	Helena	Admitted to Helena from Alice about 2nd March.

In the above table such data as may be considered noteworthy are:—
As regards—

- (a.) *The Hospital*.—Simultaneous invasion of both wings by diphtheria, and invasion (coincident nearly with diphtheria in point of time) of the south wing by scarlatina.
- (b.) *The Wards*.—Nearly simultaneous invasion by diphtheria or some throat illness, of four (three medical and one surgical) out of the five general wards of the hospital. Limitation of scarlatina, both on invasion and afterwards, to two wards of the south wing.
- (c.) *Initiatory cases*.—The five initiatory cases of throat illness in the several wards invaded had all been resident in the hospital for 13 days and upwards before attack; all of them but one for 19 days or more before they fell sick:—a circumstance that seems to indicate that the children did not themselves introduce infectious disease to their several wards. One only of these initiatory cases of diphtheritic nature was under three years of age, and this child having suffered from nasal discharge for a month, died late in the outbreak from laryngeal affection without visible implication of the pharynx.
- (d.) *After-occurrences of illness*.—In *Louisa* Ward scarlatina was followed, after intervals varying from 12 to 18 days, by scarlatina, measles, and diphtheria. In *Alexandra* Ward diphtheria was within 3 days followed by cases of scarlatina and by acute albuminuria. In *Alice* Ward diphtheria was quickly followed by diphtheria and sore throat and whooping cough; and after an interval of nearly 3 weeks by an

additional case of diphtheria. In *Victoria*, diphtheria—notwithstanding treatment in that ward of several cases of throat disease and one of acute albuminuria brought from other wards—was not followed by any illness until lapse of 14 days, when two cases of diphtheria and one of sore mouth occurred simultaneously. In *Helena*, follicular tonsillitis was not followed by infectious illness of any sort.

- (e.) *Periods intervening between presumed opportunity for contracting diphtheria and actual manifestation of the disease in particular cases.*—Period not more than 6 days in Kirby, 13 days in Warner, and 14 days in Wilson. Period not less than 9 days in Cavannah, and 14 days in Robson.
- (f.) *Apparent limitation in time of operation within the hospital of the cause of one and another disease.*—Of scarlatina: cause operative anterior to 5th March, and not after the second week of that month. Of diphtheria: cause operative anterior to 8th March, and not after (see Robson and Cavannah) 13th or 14th of March.* Of measles: cause operative in early March and not later. Of whooping cough: data uncertain.

We are therefore in face of the four following considerations, and they are independent of the nature of the “cause,” and of the means of extension of the diseases concerned:—

- (1.) Production of diphtheria in four out of five wards in both wings of the hospital, within a very limited period.
- (2.) Production of scarlatina in two wards in one wing of the building, within nearly the same period.
- (3.) Many subsequent cases of diphtheria; and during the period of their occurrence, one further case of scarlatina, one case of measles, and one case of whooping cough appearing in the wards.
- (4.) Cessation of production of diphtheria and of other diseases at about one and the same time.

In these considerations is seen suggestion of unity of the disease-material of diphtheria with that of scarlatina; and the suggestion is not a new one. But evidently it is without practical meaning in the present connexion. For not only are measles and whooping cough diseases that have never been suspected of alliance with diphtheria, also in question, but even as regards scarlatina it is plain that distribution of two several disease-materials through one common agency must be set aside before a hypothesis of unity of disease-material could usefully be entertained. Still, I have had this suggestion in view while inquiring into the conditions of diphtheria production in the hospital.

The following headings will show sufficiently the various lines upon which the inquiry has proceeded: how it has been concerned, first, with search for more direct agencies, especially for antecedent human infection; and, the results of this proving inconclusive, how it has extended to an examination of other conditions that might be supposed capable of giving rise to or distributing the matters of infective disease.

I.—POSSIBLE CAUSATION OF THE OUTBREAK BY INFECTION FROM ANTECEDENT HUMAN CASES IN THE SEVERAL WARDS OF THE HOSPITAL.

The following Table (III.) shows in regard of each of the several wards the cases of infectious and doubtfully infectious illness occurring or treated in the hospital, and the method in which each case was dealt with, from the beginning of the year up to and including the outbreak.

* The attack of the house physician by diphtheria on the 19th April is not here taken into consideration. His illness has been held to be due to infection from cases of diphtheria admitted from a distance during April.

TABLE III.

Period, antecedent to the 1st of March.			Period, 1st of March to 1st of April.	
Ward.	Invaded by	Receiving for Treatment.	Cases comprised in the Outbreak.	Remarks.
Diphtheria Ward.	—	Diphtheria, January 8th until death. Diphtheria, February 5th-10th. Died.	Diphtheria, from Alexandra, 10th March. Diphtheria, from Alice, 10th March. Diphtheria, from Alice, 10th March. Diphtheria, from Victoria 11th March.	Survivors removed to Alice Ward on 14th March.
Louise -	—	—	Scarlatina, 5th March - Scarlatina, 17th „ - Measles, 19th „ - Diphtheria, 23rd „ -	Treated in North Block. Attacked at home day after leaving hospital. Attacked at home three days after leaving hospital. Attacked at home nine days after leaving hospital.
Alexandra	—	Catarrhal laryngitis, Dec. 9th to Jan. 2nd. Catarrhal laryngitis, Jan. 21st to Feb. 5th. Diphtheria, Jan. 27th to Feb. 5th. Died. Catarrhal laryngitis, Feb. 3rd to 25th.	Diphtheria, 8th March Scarlatina, 10th „ Acute Albuminuria, 11th March.	Died in Diphtheria Ward. Treated in North Block. Removed to Victoria 13th March, and there treated.
Alice -	Measles, 6th Jan. Measles, 22nd „ (Both cases promptly removed from Ward.)	—	Nasal Diphtheria, 9th March. Diphtheria, 9th March Diphtheria, 10th „ Tonsillitis, 10th „ Whooping cough, 11th March. Sore throat, 13th March Swollen tonsils, 10th to 14th March. Swollen tonsils, 10th to 14th March. Diphtheria, end of March	To Victoria 14th March. To Alice 9th April. Died 11th April. To Diphtheria Ward 10th March. To Alice 14th March. To Diphtheria Ward 10th March. To Alice 14th March. Retained in Alice. Sent to St. Bartholomew's 12th March. Discharged, 13th March. Treated in Victoria, 13th to 22nd March. Treated in Victoria, 13th March to April. Attacked at home, and died there.
Victoria -	Membranous laryngitis, 9th Feb. (Treated in the Ward up to 1st March.)	Laryngitis, Dec. 29th to Jan. 31st. Scarlatina, Jan. 1st to 14th. Catarrhal laryngitis, Jan. 30th to Feb. 10th.	Diphtheria, 10th March Diphtheria, 24th „ Diphtheria, 24th „ Sore mouth, 24th „	To Diphtheria Ward, and died there. Removed to Alice 24th March. Removed to Alice 24th March. Treated in Victoria.
Helena -	—	—	Follicular tonsillitis, 12th March. (Admitted to Helena from Alice ward about 2nd March.)	Retransferred to Alice 13th March.

It is thus seen that cause for invasion of *Louisa* and *Helena* in antecedent human cases treated in these wards could be excluded; while as regards *Alice*, similar cause of invasion could scarcely be entertained, seeing that the only antecedent cases were two attacks by measles which occurred some six weeks before the outbreak; and that these cases of measles were followed at the outbreak, not by more measles, but by diphtheria and throat illness. On the other hand, with reference to *Alexandra* and *Victoria* wards, infection by antecedent human cases could not be excluded. Notably in *Alexandra* diphtheria had been treated within 32 days of the seizure in this ward of the

first case of the outbreak; and further, a child that had suffered from catarrhal laryngitis was discharged from the ward within 17 days of the occurrence of the first case of the outbreak referred to. Scarlatina, too, may possibly have existed in Alexandra, before the outbreak, in the person of a child who suffered on the 11th March with acute albuminuria. As regards Victoria Ward, diphtheria there occurring in early March, may, if membranous laryngitis be capable of producing it, have been related to two cases of that disease which occurred simultaneously in the ward a month previously. One of these cases, admitted 30th January for catarrhal laryngitis, developed acute laryngeal symptoms 9th February and died, notwithstanding tracheotomy, the next day; the other, admitted for ague 15th January, recovered after tracheotomy, and remained an inmate of the ward at the date of the outbreak. A single case, found to be desquamating after scarlatina in early January and at once placed in isolation, had no obvious relation with after occurrence of infectious illness in the ward.

II.—POSSIBLE MEDIATE INFECTION BY HUMAN OR OTHER AGENCY.

In this connexion conveyance of infection within the hospital from patient to patient by members of the administrative staff, its introduction from without by visitors to patients, and possible dissemination of infective material in the laundry arrangements, were considered.

(a.) *Administrative Staff*.—So far as could be ascertained, two persons only of the whole staff, the Lady Superintendent and the Registrar of the hospital, had such regular and frequent communication with all patients in all wards as might possibly have sufficed to bring about invasion so nearly simultaneous of all wards. But there is no evidence whatever that these persons had concern in production of the outbreak. Except two cases of laryngitis, one in Alexandra the other in Victoria Ward, and both of which were well (and not therefore receiving any special attention by the officers in question) several weeks before the outbreak, there was no case in the hospital proper whence they might have conveyed infection. And further, neither in the north (isolation) block, nor in the diphtheria ward, was there within three or four weeks of the outbreak any case of infectious illness with which they could have been in relation. Of course other and various members of the staff, resident and non-resident, *may about the same time* have conveyed infection from the out-patient room or from outside the hospital to patients in the wards with which they were severally and separately concerned. But explanation in this way of the phenomena of the outbreak involves a congeries of accidents altogether unlikely.

(b.) *Visitors*.—There is reason for believing that from time to time friends of patients have, by visiting the children in the hospital, conveyed to them infection, especially of scarlatina and measles. During the past winter, indeed, whooping cough is believed to have been several times so introduced to the wards. But heretofore not more than occasional cases of infectious illness occurring at irregular intervals have been attributed to infection thus conveyed; certainly, no considerable outbreak in the hospital has yet been referred to such cause. In the present instance, causation of the outbreak through introduction of disease by friends of patients seems highly improbable, not indeed on account of the magnitude of the outbreak, but for the reason that nearly simultaneous invasion by such means, of all wards of the hospital, would require not one or two but many visitors (few of whom could have had community of home circumstances) at one time capable of conveying infection. Moreover, for a considerable period before the outbreak friends of patients had less opportunity than common of infecting children in the hospital, for owing to prevalence of measles in the metropolis the bulk of visitors had been for some months excluded, admission only being given to friends of patients whose cases were urgent.

(c.) *Laundry Arrangements*.—The evidence obtained under this head was somewhat complex as well as voluminous; it has been carefully examined and weighed, but it will probably be enough that I should say of it that it yielded no evidence tending to inculcate the laundry arrangements, and indeed it tended to exclude them from having concern in the outbreak.

III.—A POSSIBLE CAUSE OF THE OUTBREAK IN THE POLLUTED AIR.

(a.) *Air polluted outside the Hospital.*—A notable source of pollution of air external to the hospital existed during the period of the outbreak, and had, moreover, limitation coinciding pretty closely with the limitation assumed in this report for the operation of the cause of the outbreak. It had to do with dust liberated in the demolition of certain dwelling-houses in Powis Place, immediately fronting, on the other side of the way, the north wing of the hospital. This demolition of dwellings commenced on 1st March and continued for about four weeks, during the whole of which period the weather remained for the most part unusually dry. As a consequence of the demolition of these houses in continued dry weather the atmosphere of Powis Place was thickly loaded during the daytime with fine dust, which entered the hospital along with the air and permeated the building throughout. It cannot be said that the north wing of the hospital, though nearer to the houses in process of removal, suffered more heavily from the dust nuisance than the rest of the building. Probably eddying currents of air brought about by aggregation of tall buildings in this neighbourhood had to do with the seemingly impartial distribution of the nuisance, for the roofs of outbuildings on the east side of the hospital (that furthest from Powis Place) were observed to be almost as thickly covered with the stuff as those in front of the main building. Within the hospital, all wards alike, with their inmates, were during several weeks subjected to the dust nuisance. Notwithstanding closure of windows and of fresh-air inlets (which was largely resorted to) dust permeated in all directions and settled, despite cleansing operations, again and again on all articles of furniture and decoration from floor to ceiling. Especially it collected in the grating-covered channels holding pipes of the heating apparatus, and on pictures on the walls and on head boards above the beds; these head boards affording, whenever they were moved, during the period in question, a shower of dust upon patients occupying beds beneath them.

It is obvious from this history that if dust of the above sort be as dust capable of conveying diphtheria and scarlatina, there is little reason for looking further for a cause of the outbreak. But demolition of old dwellings, even in crowded neighbourhoods, is a not uncommon occurrence, and heretofore outbreaks of diphtheria or scarlatina have nowhere been known to have been associated with the process. In the present instance it would seem that if dust had to do with the outbreak, it must (or some part of it must) have obtained infective character not usually belonging to dust of this sort. Accordingly inquiry was made respecting the circumstances of the houses in question. The dwellings, five in number, were old houses, and within a recent period had been greatly overcrowded. Two of them (those most recently inhabited before pulling down of the whole number commenced) had got into a dirty and unwholesome state, and their water-closets had been choked for some weeks at the time their tenants finally left them. Cases of scarlatina and measles are stated to have occurred during the winter among the inmates, but no diphtheria was heard of, unless a case a few months ago of fatal laryngitis may be considered as related to that disease. The laryngitis in question attacked a child suffering from measles, and although the fauces and tonsils were examined, no false membrane was found on them. Thus the total result of inquiry as to the character of the dust was negative, or perhaps tended to exculpate the dust as the agent in producing disease in the hospital. At all events, if it possessed infective power, the dust in question could not have been uniformly infective. The dust nuisance was by no means confined to the Children's Hospital, but affected also, though doubtless to a less extent, other hospitals and dwellings in the neighbourhood. Yet, except one case of diphtheria occurring in Great Ormond Yard about the date of the outbreak, no fatal case in the hospital of diphtheria was heard of near to these buildings; nor did it appear, upon inquiry being made, that there had been any particular prevalence of diphtheria in the neighbourhood. Further, the north wing, though from its position most exposed to the dust of the dwellings in process of demolition, cannot be said to have suffered more from nuisance arising from the dust than the rest of the hospital; yet one of its wards (Alice) suffered from diphtheria and throat illness early, and in excess of all the other wards of the hospital, while its other ward (Victoria) had up to the end of March only one case of diphtheritic nature.

Upon the whole it becomes obvious that if the dust in question had concern at all in the outbreak, the element of infectivity contained in it had effective range in no way co-extensive with that of the dust nuisance.

(b.) *Air polluted within the Hospital.*—In view of the construction of the hospital in two wings each distinct and separate from the other as regards drainage and ventilation arrangements, it appears altogether unlikely that any cause of air pollution generated within the hospital can have affected at all simultaneously the air of all the wards. Nevertheless, it is possible that air contaminated from a single source within the building may have found its way by means of the central block and its stairs into both wings; for the wards of each wing open, floor on floor, on opposite sides of these central stairs. It should be noted, however, that the central hall and stairs are ventilated freely and separately from the wings of the hospital, and that each ward is shut off from the stairs by a swing door. Still inquiry was made as to sources for air pollution in the central block; and, in regard of the circumstance that trapping of drain inlets seems to have been relied on, to the exclusion of ventilation of drains by fresh air, especial attention was paid to possible drain nuisances in the basement of the hospital. Nothing, however, was made out. Smells from drains could not be heard of except at two points, one, the waste-pipe of north out-patient drinking fountain; the other a sink-pipe in the dispensary. Both of these drain communications are held to be trapped, but reflux of air has been observed from them. Emanations from these sources have, however, been rare and trivial: they cannot well have had concern in the outbreak, for the reason that ventilation of those portions of the basement in which they have occurred is most readily effected in directions other than that of the main staircase.

With reference to a supposition that both wings of the hospital might about the same time have had their air seriously or even specifically polluted by distinct though similar causes, certain matters connected with the ventilation of wards and drains in each wing seemed to deserve notice as possibly constituting conditions wanting in uniform safety. They consisted in the circumstances that the exhaust chambers situated in the turrets of each wing communicated by shafts, not alone with the ward offices, but also with the main drain of the wing, as well as with the soil pipes, bath and other waste pipes. Further, in the north wing the diphtheria ward ventilated by shaft into the exhaust chamber of one of the turrets, which chamber received also exit shafts from the ward offices of this wing. Accordingly experiment was made to ascertain whether reversal could be effected of the air currents in the up-cast shafts leading from the bath-room and closets of the wards to the turrets, so as to convey fouled air from the exhaust chambers toward the wards. For it was seen that if this could be easily done such reversal of air currents might very likely have occurred at the period during which fresh air (by ordinary inlets) to the wards was largely excluded on account of the dust nuisance brought about by demolition of houses in Powis Place. The experiment, however, made under conditions as adverse to the system of ventilation as was practicable, failed altogether in reversing the air currents between the wards and the turrets. The details (which are unimportant) of this attempt include the circumstance that although sulphurous acid generated in the diphtheria ward readily made its way to the exhaust chamber in the turret, no trace of the vapour could be detected in the general wards of the wing experimented on.

IV.—POSSIBLE CAUSE OF THE OUTBREAK OPERATING THROUGH ARTICLES OF FOOD.

On examination of the diet cards of the children that were in-patients during the period of the outbreak, two articles of diet, water and milk, alone had such distribution as covered the incidence of the various diseases on the children attacked. Turning to the consideration of possible infection-agents such as these, as previously in the case of air and dust, a serious objection is felt by the inquirer. It is to the effect that if any one of them had to do with the outbreak, how did it happen that all patients being presumably alike exposed to such influences, so very small a proportion of the total number were seized with infectious illness. Unless this objection be met, no explanation as to a single agent in the production of the outbreak can be considered wholly satisfactory. Such evidence as appeared was to the following effect:—

(a.) *Water*.—As regards quality of the water supplied to the hospital, no suspicion attaches to it as delivered by the New River Company's mains; but in the circumstances of water storage in hospital there may have been opportunity for its contamination. The drinking-water cisterns, which are, as has been said, situated in the space beneath the roof of the central block, are uncovered cisterns, and water in them is therefore liable to contamination by dust or other material suspended in air in this neighbourhood. Whether or not the particular dust from the houses in Powis Place penetrated the space beneath the roof of the hospital which is occupied by these cisterns, I am not able to say; but it is certain that dust of some sort is to be found there in abundance. It should be noted that these cisterns have no kind of communication with the drains of the hospital, their waste pipes being conducted outside on to the roof of the building, and there ended over open lead channels. On the whole it is unlikely that the water supply of the hospital has been concerned in the production of disease.

(b.) *Milk*.—Milk in some form or other was an element of diet of all patients. In addition most patients consumed as a drink, at some period of the day or night, milk or milk-and-water. The milk supplied to and used in the wards for drinking purposes was unboiled milk. All patients that were attacked during the outbreak drank milk, or milk-and-water, at one or other of their meals to within a short period of their seizure. But numerous other children habitually consumed milk under similar circumstances without suffering from infectious illness. Probably therefore the milk supply of the hospital, if infective at all, was at no time uniformly infective. At the date of the outbreak the quantity of milk received daily at the hospital (in two or more deliveries) averaged 80 quarts, and all of this milk was obtained from one retail milk business in the neighbourhood of the hospital. Investigation respecting the methods of storage of milk in the hospital dairy, and the routine of its distribution to and in the wards, seemed to show that a comparatively small quantity of milk might be received and retained in the dairy, and subsequently be distributed in supplementary fashion, to particular patients, without at any time becoming mixed with other milk, or entering into the total milk service of a ward. If, therefore, a portion only of the total daily milk supply to the hospital had on occasions been (or had afterwards become) infective, such portion might have got distributed among the wards in some such way as would explain the phenomena of the outbreak. Further, the method of delivery of milk from the dairyman to the hospital seemed not inconsistent with exceptional supply to the institution of a small quantity of milk *differing as regards source* from the bulk of the day's delivery. It may on occasion have permitted delivery of a large quantity of milk from one or more churns, and a much smaller quantity from another vessel. But there was no suggestion that the milk, or any portion of it, delivered at the hospital by the dairyman differed in any way from that distributed by him in the operations of his somewhat extensive business in the neighbourhood, where, as has been said, no unusual prevalence of diphtheria was heard of. In short, the total evidence, though failing to exclude milk as an agent in the outbreak, did not support suspicion of it to an extent justifying detailed inquiry into the operations of this dairyman's milk business; the less so since experience has shown that investigation of this sort has sufficed before now to seriously damage the milk business inquired about. Nor was I disturbed in this judgment by the fact that the Great Ormond Yard case above mentioned chances to have been in a child among the customers of the dairy in question.

Thus I find it needful to bring this report to an end, without having arrived at any definite answer to the question how diphtheria was produced in the Hospital for Sick Children. In some particulars the constructive details of the hospital will probably be considered by the Committee as requiring further critical observation, with a view to getting assurance that all the carefully devised arrangements are doing their work efficiently and safely. I should wish to add, that had a satisfactory outcome to this investigation been for me attainable, Dr. Abercrombie's able assistance would have gone far to secure it.

W. H. POWER.

2nd June 1880.